2001

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Lewis, Ira

Penn State University Press

Lewis, Ira. "Logistics and electronic commerce: An interorganizational systems perspective." Transportation Journal (2001): 5-13.
http://hdl.handle.net/10945/64964

IRA LEWIS

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Abstract

The coordination of activities within supply chains using information technology can be described as taking place using two broad types of mechanisms, both of which use intermediaries to carry out logistics activities. These are electronic hierarchies, consisting of legally separate firms that share a close relationship within a supply chain, and electronic markets characterized by short-term linkages that result from individual transactions. A key influence of information technology on logistics is the emergence of separate but linked intermediaries for handling physical goods and the information associated with those goods.

This article is intended to provide a conceptual framework that integrates research from the fields of logistics and information systems. We hope to contribute to understanding the restructuring of logistics that is occurring with the information technology (IT) revolution and the rise of electronic commerce. Our approach is an attempt to understand logistics using insights from another management discipline, that of information systems.[1]

Corporate strategy is increasingly focused on the flow of information between buyers and suppliers. While physical goods cannot be moved as rapidly as information, expectations of what logistics processes can accomplish have risen with rapid improvements in IT. Accordingly, the physical distribution of goods is being restructured to take advantage of increased efficiencies in IT, notably in the ease of communication among the different components of the supply chain.[2]

This article begins with a discussion of supply chains from the perspective of interorganizational systems, one of the major fields of IT research. The study of interorganizational systems relies on transaction cost economics, and centers on the use of hierarchies and markets to characterize relationships between firms in a supply chain.[3] We then review the emergence of electronic commerce as an application of interorganizational systems and the impact of electronic commerce on logistics activity. The next section proposes a conceptual structure for analyzing physical and information flows within supply chains that builds on research in IT.

Mr. Lewis, AF-AST&L, is associate professor of logistics, Graduate School of Business and Public Policy, Naval Postgraduate School, Monterey, California 93943-5197; e-mail ialewis@nps.navy.mil.

Hierarchies and Markets

Supply chains represent an example of business process change enabled by *interorganizational systems* (IOS). Bakos has defined an IOS as "an information system that links one or more firms to their customers or their suppliers, and facilitates the exchange of products and services."[4] An *information system* is a set of people, procedures, and resources, whether manual or automated, that collects, transforms, and disseminates information.[5]

Information systems perform three vital roles in any type of organization: they support business operations (such as capturing point-of-sale data), managerial decision making (such as choosing suppliers), and strategic competitive advantage (for example, a firm's ability to integrate its entire supply chain). The key enabler of IOS is telecommunications and information systems, such as the Internet or private networks, that link the terminals and computers or businesses with their customers and suppliers, resulting in new business alliances and partnerships. According to Handfield and Nichols,

appropriate use of IOS provides decision makers with timely access to all required information, in an appropriate format, from any location within the supply chain.[6]

Research into the employment of IOS is based on transaction cost theory, which considers two different types of coordination mechanisms for carrying out transactions between buyers and sellers: *hierarchies* and *markets*.[7] In the context of IOS, we use the terms *electronic hierarchies* or *electronic markets* to emphasize that buyer-seller relationships are enabled by IT.[8]

In an *electronic hierarchy*, the organizations involved share a long-term relationship and align their internal processes with one another. Purchasing and distribution are accomplished by managerial decision making within and between firms in the supply chain. Cooperation between firms may tend to blur the boundaries between the companies, even if they are legally separate. While an electronic hierarchy is enabled by the efficient exchange of information between its components, such factors as personal acquaintance, mutual understanding, and trust play an important supporting role.

The emergence of electronic hierarchies to link separate firms in the supply chain represents a response to switching costs, or what Womack and Jones have described as "the massive costs of casual interactions."[9] The use of the term "electronic hierarchy" to describe an inter-firm relationship represents a change in terminology as transaction cost theory views hierarchies as existing only within single firms. The blurring of boundaries between hierarchies and markets represents one of the key impacts of IT on managerial functions such as logistics.[10]

The second type of IOS is an *electronic market* designed to match buyers and sellers who generally do not share long-term relationships, such as those who do business through a stock exchange. Electronic markets occupy a relatively neutral position between buyers and sellers, providing services to both sides of a transaction.[11] The matching process includes "price discovery," the process of determining the prices where supply and demand "clear" and exchange occurs. Markets also facilitate transactions by supporting arrangements for logistics (including order fulfillment and delivery), settlement of payments, and in some cases, providing trust or insurance to guarantee commitments made by buyers or sellers.[12]

Markets can generally be characterized as either centralized or decentralized. *Centralized* markets use one or more intermediaries such as brokers or distributors; buyers and sellers need only connect to one or more of these intermediaries to carry out a transaction–stock exchanges are a good example of a centralized market. More recently, online trade exchanges such as priceline.com, ebay.com, and the Covisint joint electronic marketplace announced in February 2000 by General Motors, Ford, and DaimlerChrysler have demonstrated the increasing importance of centralized electronic markets. The exchange planned by the Big Three auto manufacturers is expected to account for purchases of approximately $250 billion a year and involve about 60,000 suppliers. Total business-to-business ("B2B") electronic commerce is forecasted to total more than $2.7 trillion by 2004, complemented by an estimated $184 billion in online sales by businesses to consumers ("B2C"). The market research firm Forrester Research predicts that 20 percent of all trade will be handled online by 2005.[13]

As explained by Nissen, an evolution is in progress that is leading to the increasing integration of supply chain management and electronic commerce, while at the same time blurring the boundaries between B2B and B2C:

> Even the term *supply chain* is expanding in breadth to reflect its increasing scope and importance in the enterprise.... Although many researchers maintain a narrow focus on supply process activities, others ... now concentrate on interorganizational relationships between enterprise buyers and sellers, emphasizing commercial exchanges of goods, services, information and money. Indeed, the distinction is blurring between supply chain management and commerce through business-to-business markets, and many important principles and trends apply to consumer markets as well.[14]

Intermediaries add value to supply chains by reducing the cost of bringing a product to market, through actions such as aggregating buyer demand or seller production to achieve economies of scale, protecting buyers or sellers from opportunistic behavior, and matching buyers and sellers.[15]

In contrast, in a *decentralized* market, all the participants can contact each other directly, and no intermediaries are present. For example, individual travelers who directly contact an airline to arrange travel, without going through a

travel agent, are taking part in a decentralized market. Another example of a decentralized market would be one that uses intelligent agents to carry out transactions. Intelligent agents are software programs that possess knowledge (such as in the form of rules or facts) to make decisions and carry out tasks on behalf of their principals. For example, intelligent agents can match buyers with sellers and make purchase decisions based on pre-set criteria.[16]

Relationships between pairs of firms in a supply chain enabled by electronic commerce can be characterized as being hierarchies or markets, although these relationships usually consist of some variant or combination of the two. For example, there may be only one major buyer for a supplier's products. Even though the two firms may negotiate prices and other terms of exchange on an individual transaction basis (that is, in a market-like way), the buying firm will exert considerable influence on the supplier, in a manner not unlike a hierarchical relationship. The trend toward a reduction in the number of suppliers is an example of the blending of markets and hierarchies in a single supply chain.[17]

Despite the challenges of categorizing the relationships between firms in a supply chain as markets, hierarchies, or a hybrid of both, each of these two types of generalized relationships between buyers and suppliers has distinctive characteristics with respect to its cost structure. The costs of acquiring physical goods and associated services can be divided into *production* and *coordination* costs. Coordination costs include activities such as searching for a supplier, evaluating bids, negotiations, and contract administration associated with the acquisition of goods and services.

Generally speaking, coordination costs are higher when a market is used rather than a hierarchy. This is because arranging in-house production usually involves less effort than contracting with an outside firm. Conversely, in-house production costs may be higher than those associated with purchased goods, because the firm carrying out the production may not be specialized in manufacturing of the item that could otherwise be purchased from other firms. Competition between outside suppliers for the buyer's business also tends to have the effect of reducing the production costs of purchased goods.

Significant innovations in IT over the past twenty years, including the widespread adoption of personal computers linked through private networks and the Internet, have had a major impact on improving productivity throughout the economy. However, IT tends to have a greater impact on coordination costs than on production costs. This is because markets use IT more intensively than hierarchies, whose activities include in-house production. Also, as mentioned previously, markets have higher coordination costs than hierarchies. So at least from a theoretical perspective, improvements in IT should lead to a reduction in coordination costs that favors greater use of markets. The trend toward the outsourcing of manufacturing and logistics is congruent with this theory, as is the growth of online trade exchanges.[18]

ELECTRONIC COMMERCE

Electronic commerce has been defined as an application of interorganizational systems that supports the electronic trading of physical goods and of intangibles such as information.[19] Electronic commerce takes place over the Internet using applications such as web browsers and electronic mail, as well as through private networks using protocols such as electronic data interchange (EDI) or electronic funds transfer.

The rapid development of electronic commerce is in part due to the almost universal and low-cost availability of Internet access and web browser software that includes a standardized user interface. Earlier technologies such as EDI use proprietary software and require dedicated links to private networks.[20] Finally, the interactive nature of the Internet supports customer service objectives as users can rapidly and easily obtain responses or confirmation to data inputs or inquiries.[21]

Electronic commerce also represents a means of leveraging, for the benefit of buyers and sellers, the trend toward increased product customization and personalization. Information technology allows for the large-scale tracking of customer preferences, including those associated with logistics processes such as ordering and delivery. Additionally, IT permits the separation of the management and routing of physical goods flows from the processing of information relating to those goods. The informa-

tion component of logistics can be aggregated or disaggregated from the physical component, depending on the context.[22]

Electronic marketplaces such as online trade exchanges are an example of the aggregation of information from a wide variety of sources. Under a traditional scenario, a buyer of an industrial product, for example, would search trade magazines and catalogs for likely sources of supply, obtain recommendations from colleagues or sales representatives, arrange for purchase from a chosen supplier by phone, mail, or fax, and select a carrier to deliver the product. In contrast, online trade exchanges reduce the total cost of these activities by integrating and efficiently executing the different stages in the marketing, source selection, purchasing, and delivery of products.[23]

Disintermediation vs. Disaggregation

The trend toward disintermediation is closely associated with the emergence of electronic commerce. Indeed, electronic hierarchies allow buyers and sellers to communicate directly and carry out transactions without the assistance of intermediaries.[24] As explained by Chircu and Kauffman:

> Intermediaries typically provide transaction processing capabilities for buyers and sellers and thus act in an operational capacity, or they have enhanced levels of knowledge and expertise and add to the transactability of a given good or service.... Disintermediation occurs when a middleman gets pushed out by other firms, or when the services it provides become irrelevant in a marketplace that offers other ways to get the same kind of transaction done.[25]

In 1987, Malone, Yates, and Benjamin referred to disintermediation as the "electronic brokerage effect." [26] To date, evidence of disintermediation is not convincing, although the theoretical contribution of the concept is recognized.[27] Moreover, online marketplaces represent not the elimination of intermediaries, but rather the emergence of a new type of intermediary, that can perform the same functions as traditional intermediaries, such as:

- Matching buyers and sellers;
- Providing product information to buyers and marketing information to sellers;
- Managing physical deliveries;
- Providing mechanisms for financial settlement and guarantees, and ensuring the integrity of transactions.[28]

Accordingly, it might be more accurate to refer to disintermediation as *reintermediation*.[29] Nissen has pointed out that reintermediation is not limited to intermediaries that have been previously pushed out of a market. Furthermore, the motivation for disintermediation centers primarily on reducing costs, while the justification for reintermediation is related to the relative *value* of services provided by new intermediaries. In either case, for an intermediary to viably participate in a supply chain, buyers and sellers must perceive the value added by the intermediary to exceed the marginal cost of marked up prices or fees.[30]

Physical intermediaries such as warehouses or transportation carriers are still required for the execution of logistics activities. However, traditional intermediaries, such as distributors, which carry out both the physical handling of goods and the information processing activities associated with matching buyers and sellers, may be eclipsed by specialists in each of these two domains within the supply chain–a *disaggregation* of physical and information flows. As mentioned previously, for information flows these specialists include online trade exchanges that do not handle physical goods, and act only as information intermediaries. Similarly, the physical flow of goods can be handled through a third-party logistics provider (3PL).[31] As explained by Sarkar, Butler, and Steinfield, who use the term "cybermediary" to refer to the new information intermediaries:

> ... the unbundling of channel functions resulting from lower coordination costs is likely to contribute to the separation of physical distribution from other cybermediary functions. This can simplify and shorten physical distribution (e.g., Federal Express in the distribution system) while producing complex and longer networks of informational intermediaries (e.g., some firms may locate products, others provide evaluations of related products, others provide training, others provide settlement services, etc.).[32]

Emerging alliances between 3PLs and online trade exchanges support the trend toward disaggregation; each type of intermediary specializes in either physical or information flows. In the same vein, Cort has developed the following scenario:

> If IT allows suppliers to use many alternative routes to the customer to deliver the same service levels, while reducing transaction and logistical costs, the customer will be driven away from the

> traditional options, like merchant wholesalers specializing in a limited line of products. Moreover, if IT allows nontraditional options, like integrators, to reduce the customers' overall acquisition expenses across a broad range of product lines, merchant wholesaler specialists in all of those lines are threatened.[33]

Intermediaries will continue to play an important role in logistics, but their core competencies will tend to gravitate around either the physical handling of goods or the processing of information. Traditionally, intermediaries have handled both. Where complementarity between the two domains is commercially desirable, online trade exchanges (referred to as "integrators" in the quotation above) and 3PLs will form what Sawhney and Kaplan have characterized as a "patchwork of alliances."[34]

Using the terminology established previously, these relationships between online trade exchanges and 3PLs could be described as electronic hierarchies. For example, the online trade exchange E-chemicals.com has chosen Yellow Freight as its preferred logistics provider, while PlasticsNet.com and the used electronic equipment exchange iMark.com have chosen Schneider Logistics as their principal 3PL.[35]

Accordingly, future supply chains may consist of a combination of electronic markets and electronic hierarchies. Buyers will benefit due to reduced search and administrative costs, while sellers will use electronic markets to reach a wider variety of buyers. At the same time, more long-term, comprehensive arrangements will characterize key buyer-supplier relationships that take the form of electronic hierarchies.

Electronic hierarchies will be critical to maintaining product differentiation (also known as asset specificity), as commodity-like products that are easy to describe and adapt easily to market-like transactions tend to be characterized by lower profit margins. Customized features and a high level of service or product innovation can be used to differentiate products, particularly with respect to logistics activities that support transactions between buyers and sellers. As explained by Holland and Lockett:

> Rather than use IOSs to decrease the level of asset specificity and deal with larger numbers of suppliers, organizations are implementing IOSs that *increase* the level of asset specificity, either as part of an explicit strategy to tie-in customers or as a result of improving the coordination of hierarchical business relationships. The net result of these strategies is increased organizational and information technology integration across organizational boundaries, accompanied by a payoff in terms of improved responsiveness to market changes, shorter product development life-cycles, and better product quality. The evidence to support these ideas are the emergence of integrated supply chains and a reduction in the number of suppliers in many manufacturing companies.[36]

For example, an online exchange that partners with a 3PL can distinguish itself by allowing the buyer to select the mode of warehousing and delivery as well as track inventory and shipping status. An example of this trend is the partnership among logistics software firm i2 Technologies, the third-party logistics provider Ryder System Inc., and the trucking company Central Transportation International. The partnership has led to the creation of an electronic marketplace known as FreightMatrix that is designed to provide logistics support to industry-specific online trade exchanges.[37]

Emerging Structures for Physical and Information Flows

The nature of products and the evolution of industry structure will determine whether electronic markets or hierarchies are chosen to manage a buyer-seller relationship. Electronic commerce promotes a reduction in buyer search costs, i.e., the costs of obtaining information about the price and characteristics of products. When buyer search costs fall, so will seller profits, as sellers have less ability to exploit the buyer's lack of information about a product.[38]

Accordingly, sellers have an incentive to differentiate their product from their competitors, particularly when they can no longer exploit buyer search costs. One of the ways sellers can do so is by bundling their product with a variety of services such as after-sales support and warranties. Another method consists of providing efficient communications, such as customized web sites for certain clients.

As suggested by Bakos, "If sellers can control the type of electronic market introduced, they should favor a system emphasizing product information rather than price-shopping."[39] Major manufacturers increasingly recognize

that long-term profitability depends on after-sales support rather than exclusively on the initial sale of capital goods.[40] Electronic commerce supports the "bundling" of products and services through electronic markets and electronic hierarchies by exploiting efficiencies in information gathering, processing, and distribution. As Segev, Gebauer, and Färber have explained, "At least today, intermediaries are thriving that manage to provide value to market players in addition to pure aggregation and dissemination of data."[41]

Figure 1 provides an illustration of the emerging structure for information flows associated with logistics activities enabled by electronic commerce. On the left side of the figure, buyers and sellers interact via an IT node that could be an online trade exchange or web-based merchant. This relationship could be either an electronic market or electronic hierarchy, depending on the role played by the intermediary. On the far left side of the diagram, the vertical line provides another alternative–a direct relationship (or decentralized market) between buyers and sellers that does not involve an intermediary.

The central oval within the figure shows the 3PL as the intermediary responsible for arranging logistics services from individual providers such as carriers, warehousing firms, or order fulfillment specialists. On the right side of the figure, an online transportation or logistics exchange provides a means of buying and selling services involving those logistics services providers. Like the relationship between buyers and sellers, transportation or logistics exchanges could be exclusively of a market-like nature, emphasizing, for example, load-matching of trucks with freight, or could evolve into the more integrated relationships usually associated with electronic hierarchies.

Accordingly, the relationship between a 3PL and its suppliers can take the form of an electronic market or hierarchy, depending on the circumstances. However, the relationship between the online exchange and the 3PL (the bold line connecting the two sides of the figure) would be characterized as an electronic hierarchy because the exchange will tend to desire longer-term relationships with a small number of 3PLs.[42]

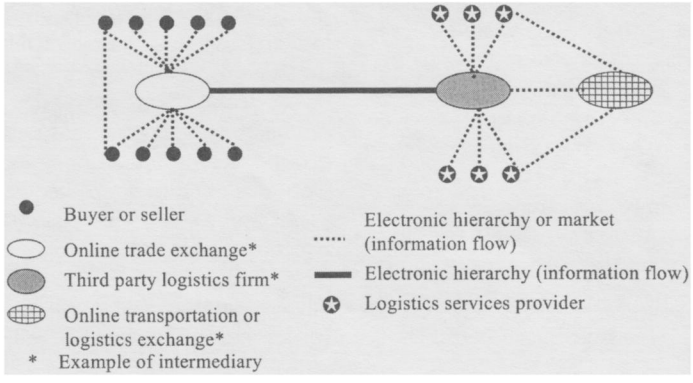
Conclusion

This article has discussed how the evolution of IT has led to the restructuring of logistics into two separate yet linked domains. One domain deals with physical goods flows, the other with the flow of information associated with those goods. Electronic commerce represents a means of carrying out the trading of goods and information through interorganizational systems. These systems use hierarchies, markets, or some combination of the two to coordinate transactions within supply chains.

The rapid development of electronic commerce has led to the emergence of online trade exchanges that represent a form of centralized electronic market. Because these exchanges deal only with information flows, many of them are entering into strategic alliances (or "electronic hierarchies") with third-party logistics firms. The 3PLs manage the physical flows that result when the online trade exchanges match buyer and seller requirements.

Lambert and Cooper recently stated that there is a need for "building theory and developing normative tools and methods for successful SCM [supply chain management] prac-

Figure 1. Information Flows in Electronic Commerce



tice."[43] Congruent with that view, a workshop sponsored by the National Science Foundation emphasized the need for interdisciplinary dialogue in electronic commerce research, and concluded as follows:

> In its broader usage, electronic commerce extends into all aspects of social and economic activities being reorganized by computers and networking. Electronic commerce, defined narrowly as "selling and buying on the Internet," is a deceptively simple idea, but its far reaching implications [are] in enabling a new networked economy where the organizational complexity and procedural interdependency necessitate that we examine current issues and future directions for basic research with a multidisciplinary focus.[44]

Within the same spirit, this article has proposed a theoretical framework for analyzing the flow of goods and information through supply chains enabled by electronic commerce. We believe that conceptual interdisciplinary research into logistics challenges merits attention, and that such work could also form the basis for useful empirical research. Indeed, the study of distribution channel structures has been described as "a fundamental research task."[45] The use of insights from other disciplines is not new to logistics; for example, research from fields such as business strategy and marketing has considerably enriched knowledge about logistics, particularly during the past ten years.[46]

We have attempted to draw on research in the field of information systems to assist in understanding the evolution of logistics, particularly given the significant impact that IT is having on all sectors of economic activity. In writing this article, we sensed that research in logistics could benefit from the rich literature that exists in IT fields such as interorganizational systems and electronic commerce. As Sarkar, Butler, and Steinfield pointed out, the physical paths that goods traverse are being simplified, in part due to the growth of outsourcing in logistics.[47] However, the capture, storage, processing, and dissemination of information related to physical goods has grown far more complex with the rise of electronic commerce. Both researchers and practitioners in logistics will need to shift their focus to accommodate the requirement to manage and analyze complex information flows. As an editorial in the February 2001 edition of *American Shipper* observed:

> There is a huge demand for better, network-based information sharing systems that speed up international transactions, enabling shippers to predict total logistics costs, re-route shipments while in transit and make the right management decisions based on up to date data. This is a learning process and the most important lesson already learned is that business information and data [are] like pure gold when properly organized and converted into a usable, digital format with the right execution and business experience behind it.[48]

This article has cited a small portion of the logistics-related research in IT that deals with subjects such as buyer-seller relationships, the impact of supplier base reduction, and the implementation of supply chain management practices.[49] At the moment, journal articles and conference proceedings in logistics management typically contain very few or no references to IT research publications. We believe there is considerable opportunity and potential for interdisciplinary research that integrates insights from the fields of logistics and information technology.

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[41] Segev, Gebauer, and Färber, op. cit.; Sarkar, Butler, and Steinfield, op. cit.
[42] Connie Gentry, "LIT [Logistics Information Technology] News for the New Year," *Inbound Logistics* 20, No. 1 (January 2000): 223-226; see also Bakos and Brynjolfsson, op. cit., for an explanation of the trend toward a reduced number of suppliers.
[43] Douglas M. Lambert and Martha C. Cooper, "Issues in Supply Chain Management," *Industrial Marketing Management* 29, No. 1 (January 2000): 65-83.
[44] *NSF* [National Science Foundation] *Workshop-Research Priorities in Electronic Commerce: September 10-12, 1998*, IC² Institute, University of Texas at Austin. Available at <http://cism.bus.utexas.edu/workshop/ecdraft.html>.
[45] Sarkar, Butler, and Steinfield, op. cit.
[46] See, for example, Stephen R. Clinton and David J. Closs, "Logistics Strategy: Does It Exist?" *Journal of Business Logistics* 18, No. 1 (1997): 19-44; Joseph L. Cavinato, "A General Methodology for Determining a Fit Between Supply Chain Logistics and Five Stages of Strategic Management," *International Journal of Physical Distribution and Logistics Management* 29, No. 3 (1999): 162-181.
[47] Sarkar, Butler, and Steinfield, op. cit.
[48] Philip Damas, "e-Commerce still flourishing," *American Shipper* 42, No. 2 (February 2001): 88.
[49] Those interested in information systems research that is relevant to logistics may wish to review publications such as the *Journal of Management Information Systems, Management Information Systems Quarterly,* the *Journal of Organizational Computing and Electronic Commerce,* the *International Journal of Electronic Commerce, Communications of the ACM, Information Systems Research,* and *Organization Science.* Also, the ISWorld web site (http://www.isworld.org), sponsored by the major academic information systems research associations and publications, provides a comprehensive gateway to academic, business, and government information systems research.